The Future Need for Energy Storage

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The future European energy landscape – short and longer term

- Energy storage is used extensively already now
- Many European countries are planning for fossil-free – or close to - energy supply by 2050
- Since the catastrophe in Fukushima nuclear power is reluctantly considered a future option

aafintl.com

whowhatwhy.com

whowhatwhy.com

ecofriend.com

- European energy supply will be taken over by renewable sources

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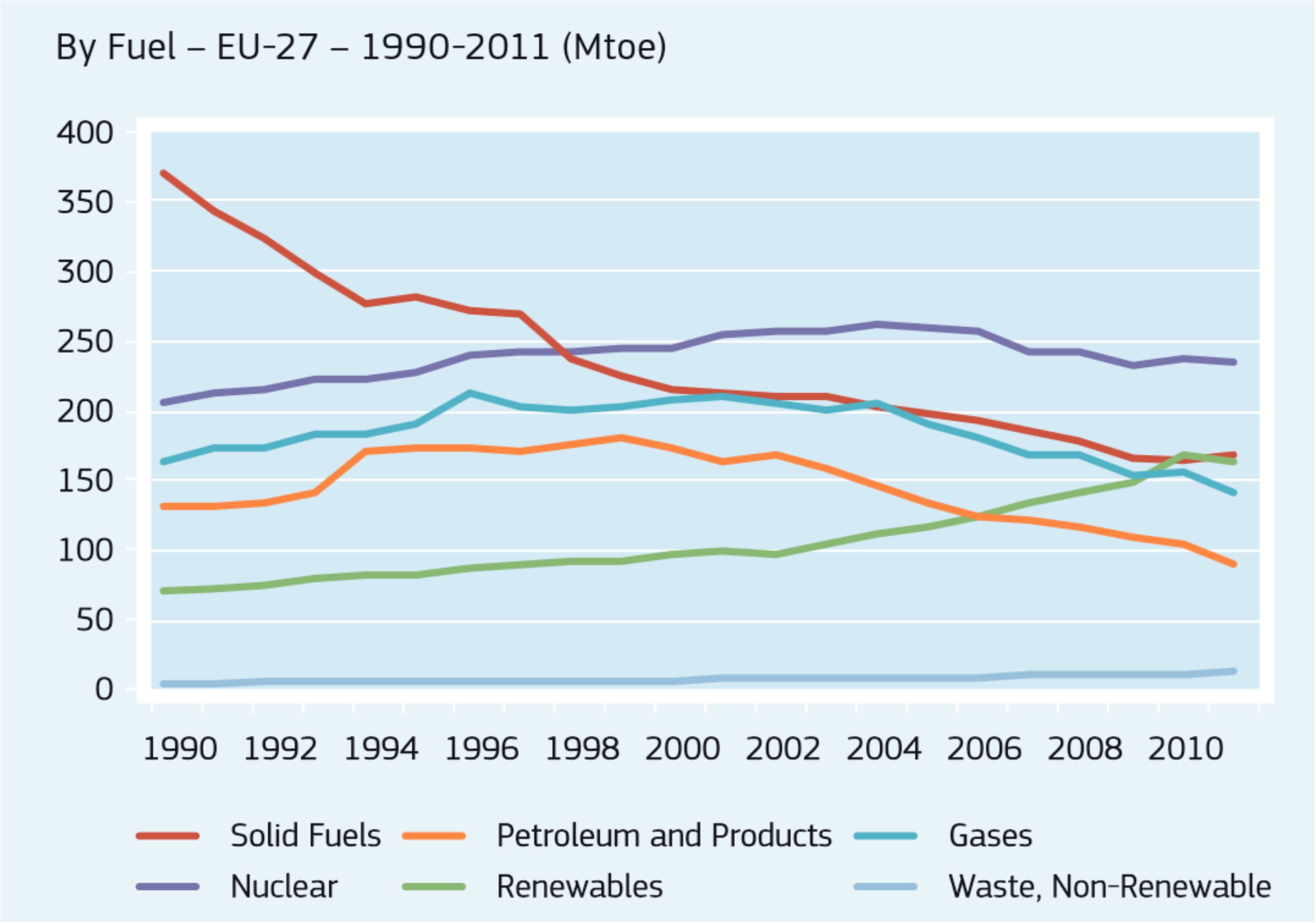
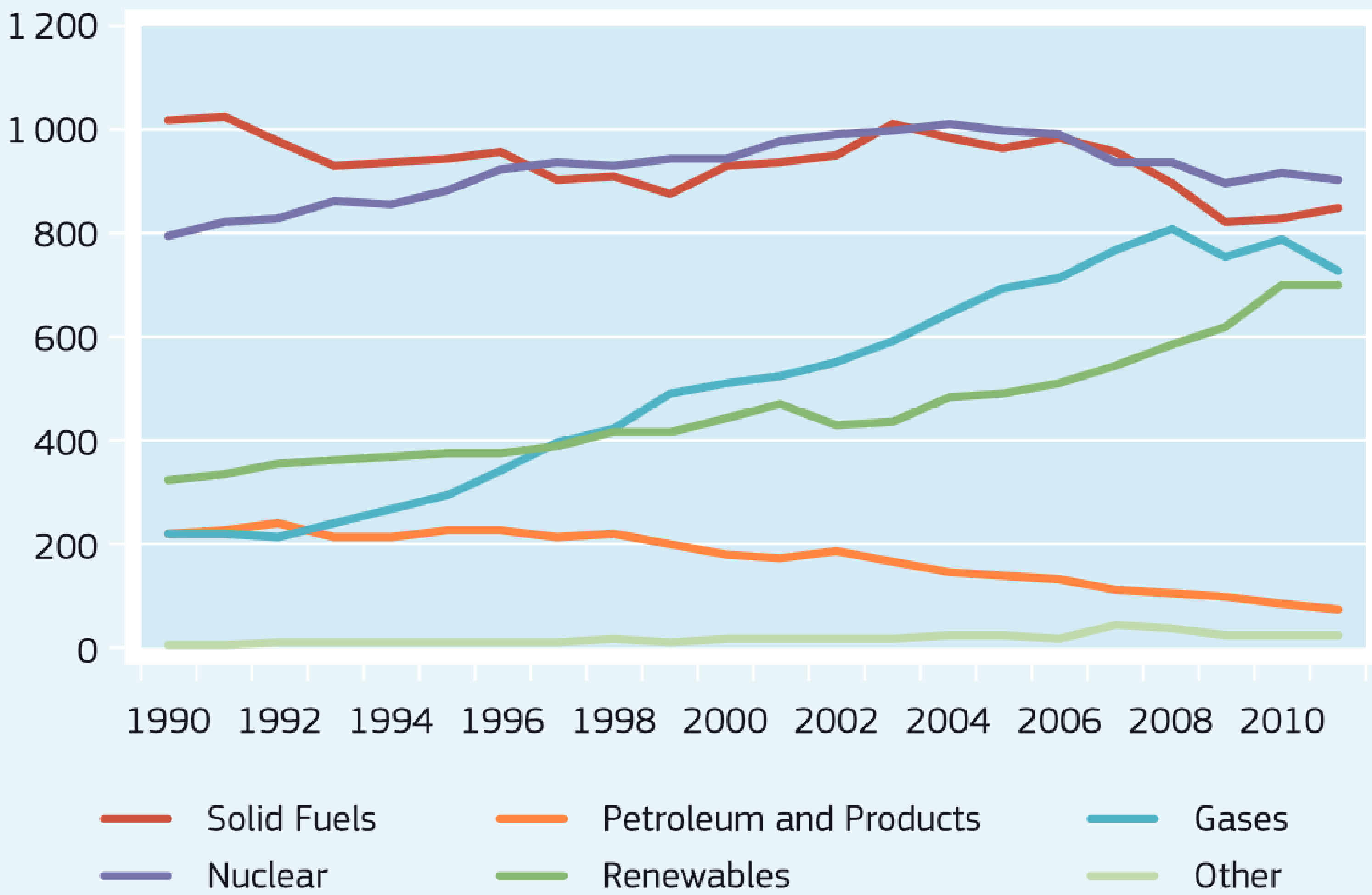
EU primary energy production



Source: EU energy in figures
European Commission 2013

EU-27 – Gross Electricity Generation – By Fuel – 1990-2011 (TWh)



Source: EU energy in figures
European Commission 2013

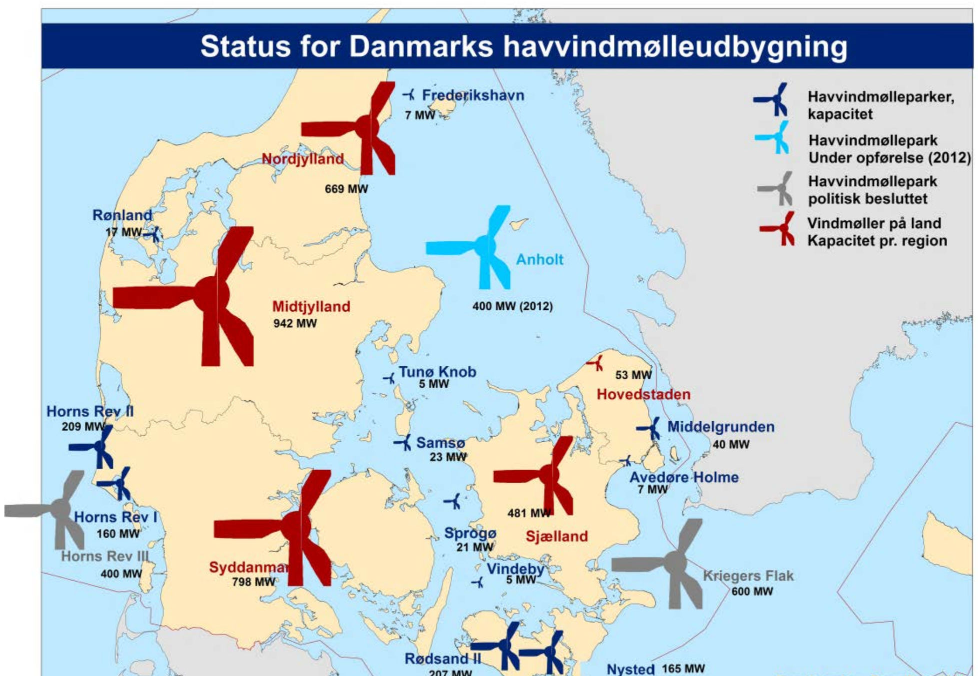
EU-27 final energy demand

	1995	2011
Transport	303	364
Households	282	273
Industry/agriculture	361	311
Services	126	155
Sum	1072	1103

Source: EU energy in figures
European Commission 2013

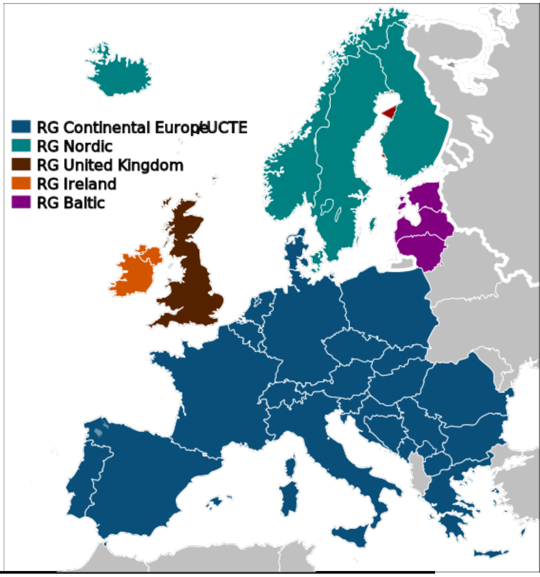
Generation capacity in Denmark

- After commissioning the Anholt Off-Shore wind mill farm (400 MW) Denmark now has 4500 MW installed wind power capacity
- New capacity is planned to reach 50% electricity from wind in 2020 and 100% in 2035
- Present thermal generation capacity in Denmark is about 6 + 2 GW
- Thermal generation capacity is decreasing these years



Ancillary services

Are services required for the security and stability of the transmission system and for maintaining the quality of electricity supply



Presently, Energinet.dk buys the below ancillary services

DK1 – West Denmark

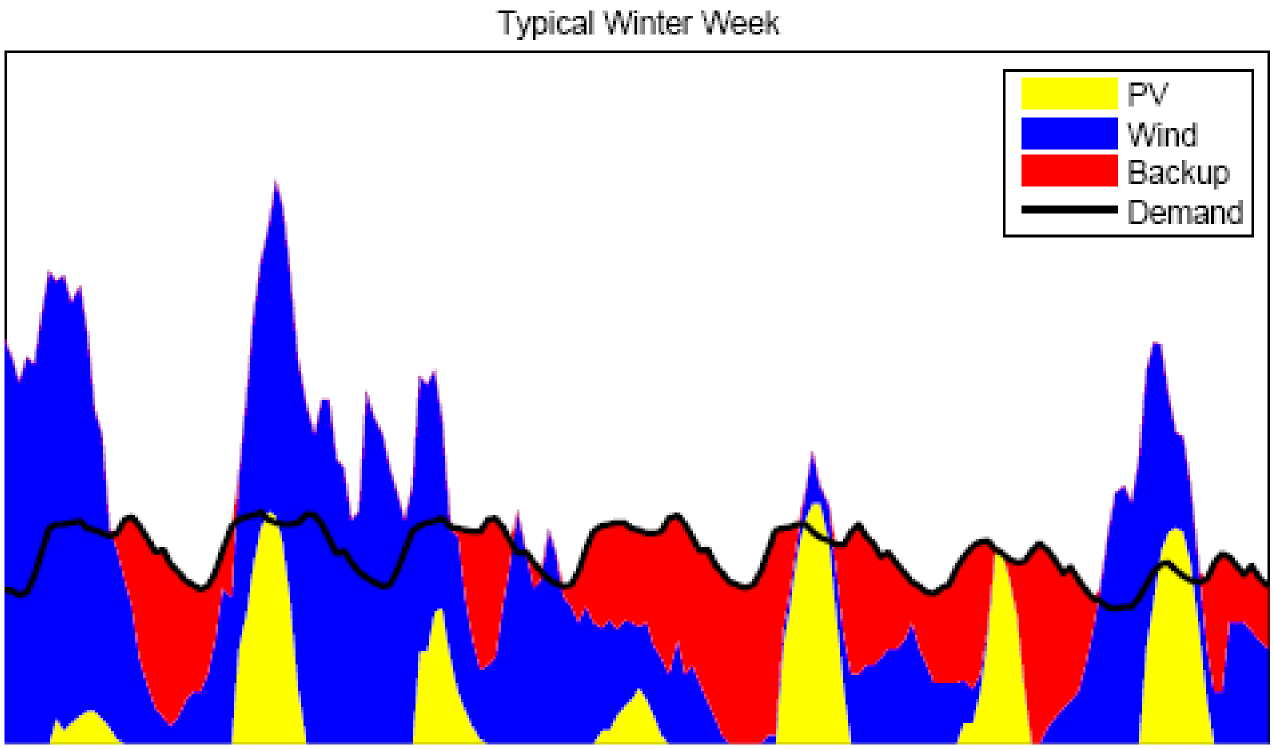
- **Primary reserves - 26 MW**
  Proportional to frequency deviation, 50% 15 s, 100% 30 s, maintain 15 min
- **Secondary reserves (LFC) - 90 MW**
- **Manual regulating reserves**
- **Black start services**
- **Short circuit power, reactive power and voltage control**

DK2 – East Denmark

- **Frequency controlled operational disturbance reserve - 23 MW**
  Proportional to frequency deviation and completely within 150 s
- **Frequency controlled normal operational reserve 175 MW**
- **Manual regulating reserves**
- **Black start services**
- **Short circuit power, reactive power and voltage control**

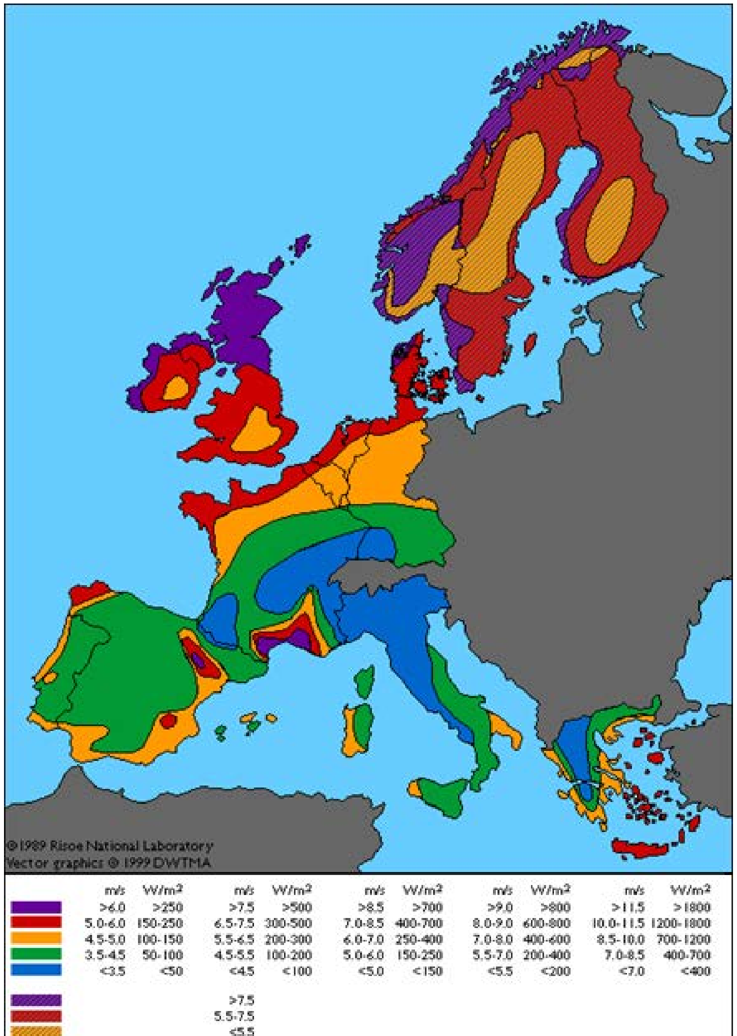
Need for energy storage over longer time periods

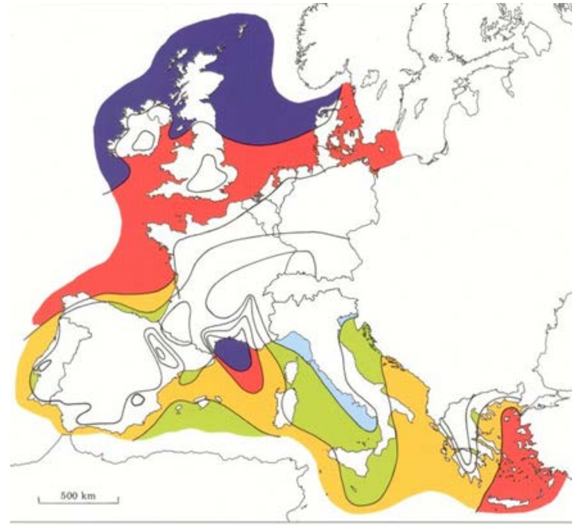
PV and wind power production as well as demand in one week – an example from Germany



Steinke, Wolfrum and Hoffmann, 2012

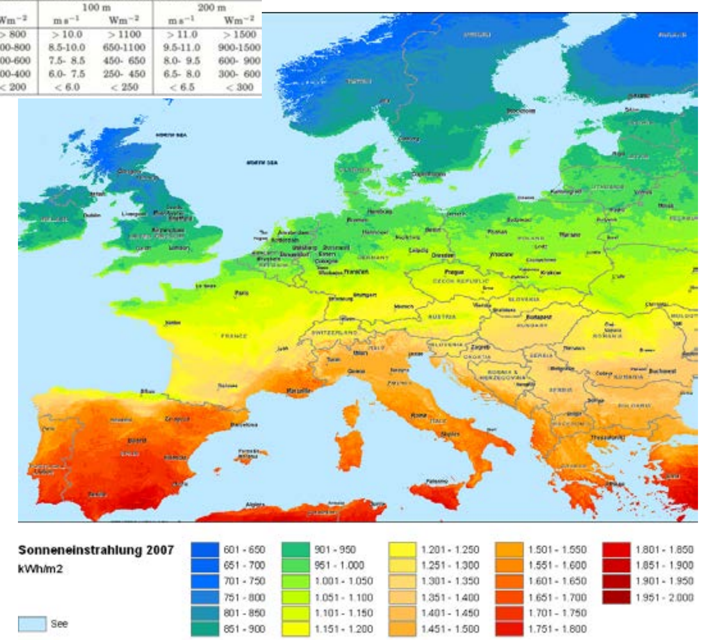
Solar and Wind Power Potential in Europe





Wind resources over open sea (more than 10 km offshore) for five standard heights

10 m		25 m		50 m		100 m		200 m	
$m s^{-1}$	$W m^{-2}$	$m s^{-1}$	$W m^{-2}$	$m s^{-1}$	$W m^{-2}$	$m s^{-1}$	$W m^{-2}$	$m s^{-1}$	$W m^{-2}$
> 8.0	> 600	> 8.5	> 700	> 9.0	> 800	> 10.0	> 1100	> 11.0	> 1500
7.0-8.0	350-600	7.5-8.5	450-700	8.0-9.0	600-800	8.5-10.0	650-1100	9.5-11.0	900-1500
6.0-7.0	250-300	6.5-7.5	300-450	7.0-8.0	400-600	7.5- 8.5	450- 650	8.0- 9.5	600- 900
4.5-6.0	100-250	5.0-6.5	150-300	5.5-7.0	200-400	6.0- 7.5	250- 450	6.5- 8.0	300- 600
< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 6.0	< 250	< 6.5	< 300



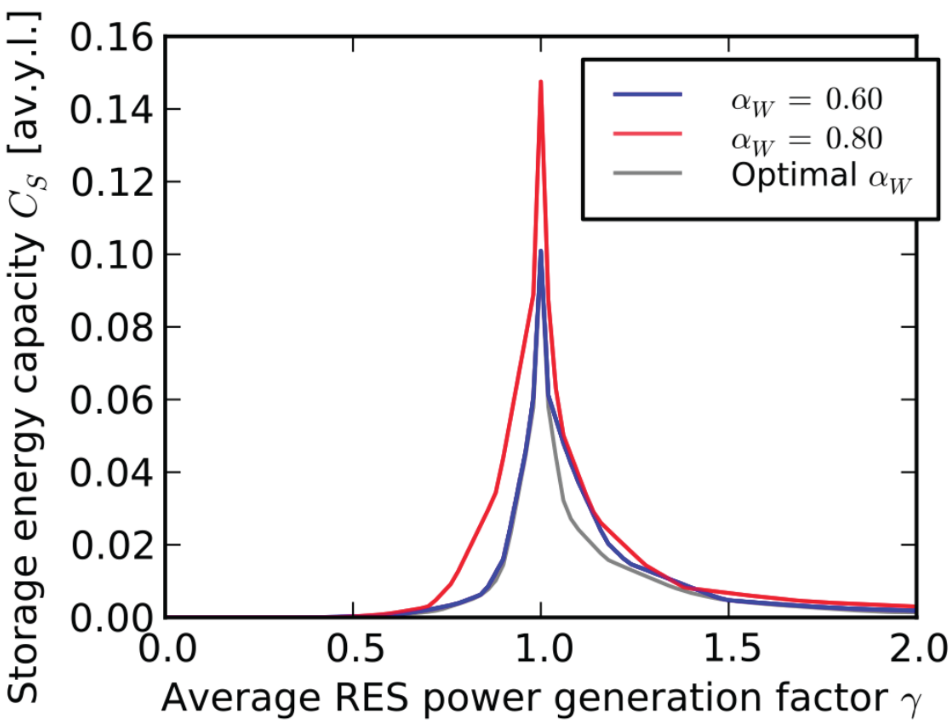
focussolar.de

Storage need derived from data

- **EU-27 weather data 50x50 km²**
- **Load data over 7 years**
- **EU 2020 targets for installed renewable generation capacitiy**

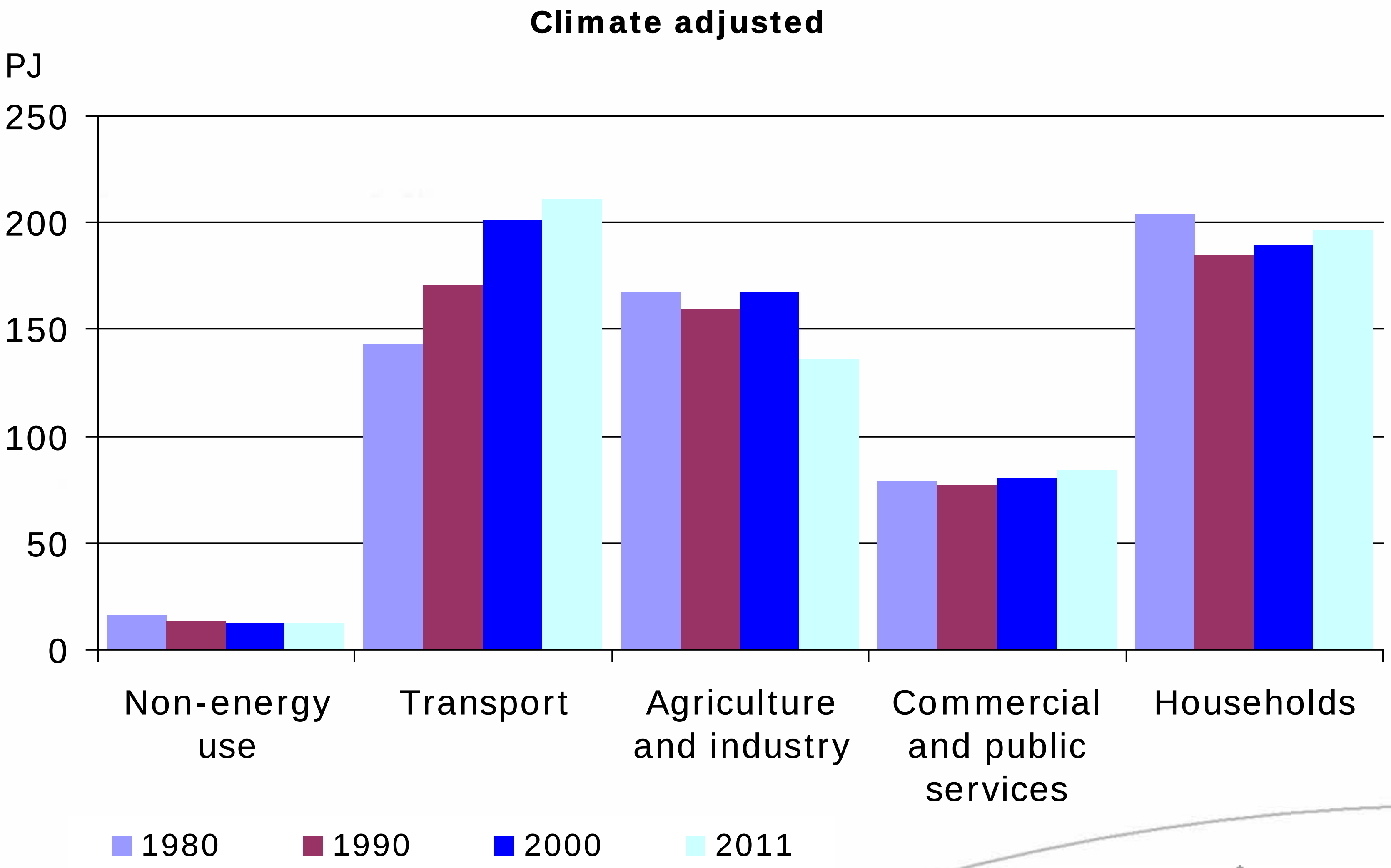
$\Delta(t) = G_W(t) + G_S(t) - L(t)$

$S(t) - S(t\text{-}1) = \eta_{in} \cdot \Delta(t)$ or $\eta_{out}^{-1} \cdot \Delta(t)$ (if $\Delta(t) < 0$)



Source: Greiner and co-workers, Aarhus University

Final energy consumption by use



Storing energy

Energy density for different materials

	w-% H	g H/l	kJ/ml	kJ/g
Hydrogen at 700 bar	100.0	17	6.0	141.0
Magnesium Hydride	7.6	101	14.4	10.9
Complex Hydride	12.0	120	16.9	17,0
Methane at 700 bar	25.0	64	17.2	55.7
Liquid Hydrogen	100.0	70	10.0	141.0
Methanol	12.5	99	18.0	22.7
Gasoline			33.4	47.6
Lead/Acid Battery			0.3	0.2
Advanced battery			2.0	0.9
Liquid Methane	25.0	106	25.0	55.7
Liquid Ammonia	17.6	120	17.9	25.2
Fly Wheel				0.5

Numbers do not include weight of containment and system components

Joint EASE/EERA recommendations for a

European Energy Storage Technology Development Roadmap towards 2030

Mission and objectives

- **Recommendations for R&D actions** in the timeframe of Horizon2020
- Point out **European needs and define technology areas** for R&D
- Set up **milestones**
- **Recommendations on strategic stakes** for optimising European R&D efforts
- **Identify critical energy storage technologies** and/or **technology gaps** that must be filled to meet technology performance targets
- Identify ways to leverage R&D investments through **coordination of research activities**
- Identify **regulatory hurdles and market failures** preventing the creation of business cases for energy storage.

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Promising technologies for next decades

Overall selection criteria:

- **Present state** of European competences in Industry and Research
- **Potential** for development to market-based deployment
- Assessment **of future requirements** in Europe within different segments such as generation, transmission, distribution
- Time horizon of **10-20 years**
- Present **industrial maturity**
- *Potential* market status for the technologies after appropriate development
- Social acceptability

Electricity Storage Technologies

- Pumped hydro storage – PHS
- Compressed Air Energy Storage – CAES
- Batteries
  - Flow batteries
  - Solid or semi-solid batteries
- Supercapacitors
- Flywheels
- SuperConducting Energy Storage
- Chemical fuels
  - Hydrogen
  - Other gaseous fuels as well as liquid fuels

- Heat Storage – district heating, small private heat storage facilities

How can energy storage support present political goals?

By facilitating integration of renewables in the energy system

- Balancing Demand & Supply
- Managing Transmission & Distribution grids
- Promoting demand side management
- Contributing to competitive and secure electricity supply
- Allowing fossil-free transport

European Energy Research Alliance

European Association for Storage of Energy

Electrical Energy Storage applications

Conventional Generation	Transmission	Distribution	Customers Services
Black start	Participation of the primary frequency control	Capacity support	End-user peak shaving
Arbitrage	Participation to the secondary frequency control	Dynamic, local voltage control	Time-of-use energy cost management
Suport to conventional generation	Participation to the tertiary frequency control	Contingency Grid Support	Particular requirements in power quality
Renewable Generation[8]	Improvement of the frequency stability of weak grids	Intentional islanding	Continuity of energy supply
DG Flexibilty	Investment deferral	Reactive power compensation	Limitation of upstream disturbances
Capacity firming	Participation to angular stability	Distribution power quality	Compensation of the reactive power
Limitation of upstream perturbations		Limitation of upstream perturbations	
Curtailment minimisation			

e.g. Chemical energy storage

What is **Chemical** energy storage?

- Short description of technologies and processes

What is the **maturity** of the technology?

- E.g.: Mature/demo/pilot/R&D…

What are the **applications**?

- Based on pre-established applications along the electricity value chain

What are the **SET Plan targets** for that technology towards 2030 and beyond?

- List of priorities analysed according to state-of-the-art, target 2020-2030 and ultimate goal

e.g. Chemical energy storage

What are the **gaps** between targets and present performance?

- List of gaps

What are the **research needs** for improving the technology?

- E.g.: material research, demo…

What are the **resources** and **infrastructure** necessary?

- E.g. financing, public acceptance, skilled manpower…

Market and policy issues

- Energy storage has a **systemic nature**
- **Aggregation of different applications** for the same storage device
- A **legal framework** for energy storage **at EU level** must be established bearing in mind that the completion of the European single market for energy is crucial
- Energy storage constitutes a **special and important asset** of the complete energy value chain.
- **Grid fees, taxes and similar** should not be allowed to hinder or discriminate the integration of energy storage
- **Market based storage solutions** should be preferred whenever possible (grid safety, however, must always take precedence)

Vattenfall 1060 MW PHS plant in Goldisthal, Germany

Recommendations given in the roadmap

- Detailled recommendations related to specific technologies
- Strategic recommendadtions concerning industrial development, demo- and pilotplants
- Roadmap can be found at:

http://www.ease-storage.eu/tl_files/ease-documents/Events/2013.04.17%20Launch%20EASE_EERA%20Roadmap/Roadmap%20&%20Annex/EASE%20EERA-recommendations-Roadmap-LR.pdf

….. many thanks for your attention